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HEARING TITLED
COMMERCIAL WEATHER DATA: COLLABORATIVE EFFORTS TO IMPROVE FORECASTS, PART 2

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Chairman Bridenstine, Ranking Member Bonamici, and Members of the Subcommittee, I am Vice Admiral Manson Brown, Assistant Secretary of Commerce for Environmental Observation and Prediction and Deputy Administrator for the National Oceanic and Atmospheric Administration (NOAA). Thank you for the opportunity to testify before you today on this important topic.

The Societal Challenge

Few environmental phenomena affect our economy, ecosystems, and livelihoods more than weather and climate. Severe weather and climatic extremes pose risks to human health, safety, and property. Understanding and responding to weather, both routine and extreme, influences the patterns of everyday lifer:

- Every morning, we seek weather updates to give us an idea of the conditions at the city block or neighborhood level, either on our favorite television or radio station, on the internet, or with a simple click of our thumbs on our smartphone Apps.
- Citizens and businesses in the Midwest and southern states prepare for and respond to the spring severe weather season. Some wonder - why can't we have one hour advance warning of a tornado versus 15 minutes?
- Residents across the U.S. Gulf and Atlantic coasts, and the Caribbean spend the summer with one eye on their activities and the other on the latest tropical weather development off the west coast of Africa.

- Millions of residents on the West Coast and Southwest who are living in a perpetual state of severe drought, increasingly demand to know when the crippling drought might break.
- U.S. businesses investing here in the U.S. and overseas want to know if their capital is being placed at unnecessary risk from weather events
- Our military relies on accurate and timeline weather information for situational awareness to achieve mission success and to protect the lives of our service men and women when defending U.S. national security at home and overseas.

The weather-related needs and expectations of Americans worldwide are of central concern to NOAA's operational and research scientists. The challenge to deliver these products and services that we constantly strive to improve is dependent on four major capabilities:

- Quality, quantity, relevance, and timeliness of data (satellite and *in situ*)
- Computing capacity (operational and research)
- Data assimilation and numerical model prediction
- Forecaster knowledge, skill, and ability

This testimony will focus on two key points that need to be considered carefully as potential commercial supplier models are evaluated: the value of the U.S. "free & open" data policy and current global data sharing arrangements, and the need for pre-purchase demonstration of data quality, sufficiency and reliability.

World Meteorological Organization (WMO) Resolution 40 and Data to Support the National Weather Enterprise

NOAA's role of providing the Nation's weather forecasts through the National Weather Service (NWS) has developed through 100 years of performing this service. Over the years, our ability to deliver the weather forecast has evolved to meet the growing need for more local and precise forecasts. Our weather research, aided by data from radars, aircraft, radiosondes, oceanic buoys, and satellites and modeled on our high performance computers, has shown us the complex links in the ocean-atmospheric interaction and the atmospheric "rivers" that drive our one to seven day weather forecast. One only needs to look at the El Niño Southern Oscillation (ENSO) phenomenon and its known impacts on the water cycle and hurricane behavior to understand the need for large scale and global datasets to inform our decision-making.

Long before WMO resolution 40, the notion that free and open access to data across international borders was important to economic and commercial development. Radiosondes were launched worldwide in the 1940s and 1950s to improve global weather prediction. They are still critical sources of data today. The WMO, the first organization within the newly formed United Nations, ensured free and open access to the data worldwide. These data were critical to building global commercial airline routes and dramatically expanding the commercial airline business.

The free and open sharing of radiosonde data through continued throughout the Cold War as the United Stated and the Soviet Union continued to make their observational data available to one another. Radiosonde data sharing occurred from Cuba even during the Cuban Missile Crisis. WMO resolution 40 was developed in the spirit of free and open access, improving the global economy through the commercial sector's use of the data, which they could not afford on their own.

Weather patterns over Asia and the Pacific form the basis of the weather for much of Alaska and the West Coast of the United States; similarly, Europe monitors the weather over the United States since our weather will be theirs within 5 days. Simultaneously, Asia watches the European weather as a precursor of what is coming, and the circle closes with the United States monitoring Asia's weather trends. Additionally, weather off the west coast of Africa could potentially spawn hurricanes in the Atlantic basin. All of these data are vital to U.S. global security and commercial interests, both within our borders and for our citizens and companies abroad.

Our ability to monitor these global weather and environmental phenomena that affect the United States is based on our ability to access data when we need it, in a format that we can use, and with the necessary assurances that we can trust it for input into our numerical weather prediction models. These data come from a variety of sources including other nations' weather stations, surface weather radars, ocean buoys, and government and commercial satellites. These data are transmitted in near-real-time to the United States for use in our short-term weather forecasting and as input to our longer-term numerical weather prediction models. The more data we receive, the better our predictions become. These data are a prime example of data that is covered by WMO Resolution 40 and the direct benefits to the U.S. taxpayer from this type of exchange. That is why the free and open exchange of data globally has been the U.S. position in many bilateral and multilateral fora.

There has been a lot of discussion about the role WMO Resolution 40 plays in NOAA's views toward commercial weather data. WMO Resolution 40 does not apply only to NOAA; it applies to the United States as a whole, and supports our U.S. data policy and principles.

While there is space to apply national data policies and principles, when interpreting what is allowable or required under WMO Resolution 40, not open to interpretation or debate are the data sets we are obligated to share under Annex 1. WMO Resolution 40 stipulates that Member countries shall provide, on a free and unrestricted basis, essential data and products which are necessary for the provision of services in support of protection of life and property and the well-being of all nations, particularly those basic data and products, as, at a minimum, described in Annex 1. Annex 1 has eight subsections that detail the types of data deemed essential and that must be free and unrestricted. Subsection eight specifically addresses satellite data and products

and calls for "those data and products from operational meteorological satellites that are agreed between WMO and satellite operators. (These should include data and products necessary for operations regarding severe weather warnings and tropical cyclone warnings)." Data not covered in Annex 1 is considered additional data and each country determines the data rights and access terms associated with additional data sets. This "additional data" categorization affords the National Weather Service the ability to enter into a licensing agreement for lightning data. This distinction is important because it may be assumed that the United States has flexibility to choose which data sets to restrict and which ones to not restrict, and that is not the case.

Although WMO Resolution 40 has not been changed, it is reviewed before each WMO Congress, which meets every four years. During one of the reviews, it was determined that Resolution 40 did not effectively address hydrological data and resulted in WMO Congress passing WMO Resolution 25, Exchange of Hydrological Data and Products.

Further, WMO Resolutions 40 and 25 do not solely drive the U.S. data principles and policies, but rather reinforce and support our belief that government data, sourced with tax payer dollars, is a public good and has more benefit to the overall weather enterprise when it is unrestricted. This applies internationally too. As we exchange more data from around the globe, our models, products and ultimately the forecasts out of the National Weather Service's local forecast offices improve. There is reciprocity in the global sharing of WMO Resolution 40 essential data. On a whole, the rate of exchange is nearly 3 to 1, in that NOAA's receives three times more meteorological data than it provides to the international community. There are also benefits domestically as certain sectors of the private weather industry in the United States benefit from our data policies. Companies are able to obtain our data and products, add value or innovate off these data to provide additional services to the public and/or key sectors of the U.S. economy, such as the transportation, agricultural, and energy sectors. With international commerce and business interests abroad, U.S. civilians and businesses use weather and environmental information on all continents. Similarly, for our national defense, NOAA provides access to its data and information products and services to all Department of Defense services and the U.S. Coast Guard as they implement their global missions.

There is also global exchange of numerical weather prediction model output. The popular press falsely pits the "European" and the "U.S." models against each other. Although exchange of model output is not governed by WMO Resolution 40, it is crucial to maintaining and enhancing our forecasting capabilities. Research and operations have demonstrated that model ensembles - a combination of different model runs - increase forecast accuracy and reliability. The sharing of model outputs provides a much larger set of ensembles, leading to better overall forecasts, especially for extreme events.

NOAA's ability to monitor global weather and environmental trends hinges on access to relevant, high-quality, and timely data.

NOAA as the Environmental Intelligence Agency

With all these streams of data and model outputs, where does NOAA fit into the picture?

NOAA is America's Environmental Intelligence agency. This means we provide timely, actionable, reliable, science-based information and products that citizens, communities, and businesses need to stay safe and operate efficiently. The cornerstone of this work is perhaps NOAA's most distinctive role among all Federal agencies, and that is the capability for practical weather prediction. As discussed above, NOAA's ability to deliver Environmental Intelligence starts with keeping the pulse of the planet, especially the atmosphere and the ocean, and this is the central capability where space-based assets come into play.

Environmental Intelligence provides us with life-saving situational awareness, and equally powerful insight and perspective about the conditions of the environment around us. Environmental Intelligence provides us with foresight, the ability to look ahead, anticipate future conditions, and assess alternative courses of action we might take to make our society more resilient and better prepared.

Finally, Environmental Intelligence provides citizens pressing their smartphone apps, or listening for weather updates on their favorite television or radio station, the appropriate information in the right context for them to make intelligent decisions about their daily lives, including protection from extreme weather. Americans do not care if the information came from a U.S. or international government or commercial satellite, or whether the model output was U.S. or European. They simply expect that NOAA will perform the necessary analyses and provide them with actionable information for their use.

Looming Challenges

Earth is warming and this will lead to more extreme weather and water events, and more intense extremes. The planet's population continues to grow. By 2040, today's 7 billion Earth inhabitants will become 9 billion – an increase of 28 percent. Because of population growth, increased standards of living, and economic development, resource margins will be stretched even thinner, putting greater strain on water, food, energy, and ecosystems. The water-food-energy nexus, which includes the interplay with and impact on the world's natural ecosystems, is already critical and will become more so in 2040. All of these factors lead to greater societal vulnerability in the locations where humans increasingly concentrate, be it larger U.S. towns and cities in the South Central "Tornado Alley," in arid locations that rely on water sources hundreds of miles away, along major rivers that flood with increased frequency, or within 50 miles of the coast (where over 80 percent of our population now lives).

As NOAA provides the Environmental Intelligence needed to navigate ever changing weather patterns, we must also plan for the weather support that will be needed in the future. These data,

which are regulated in over 20 different statues, policies and regulations,[1] are critical for federal, state, local, and tribal planners as they assess the best ways to build resiliency at the societal and community levels today and well into the future.

As NOAA works with its federal, state, local, and tribal customers and users to prepare for the future, protecting and enhancing access to data is foundational.

The Changing Paradigm

An accurate forecast three or more days in advance can be made only when the entire globe has been measured by both satellites and *in situ* sensors. Since no single entity - no government, no university, no private company, no entrepreneur or scientist - has the wherewithal to do this on their own, a global system of systems that seeks to maximize free and open sharing of data has developed. This highly successful model dates back to the earliest, pre-satellite days of weather forecasting. Today, there are many other sources of data.

In the 1960s when the first NOAA and Department of Defense operational weather satellites were launched, the government was the only entity with the resources and know-how to build these machines. Today, the U.S. Government is no longer the sole provider of Earth Observation satellite data. NOAA relies on other national space and meteorological agencies to supplement our data needs. Simultaneously, international space agencies have developed competence in development of Earth Observation missions that have proved extremely useful to support U.S. data needs. The satellite data we get from other governments improves the amount and accuracy of our satellite data by about 2X at their expense – a tremendous value made possible by our free-and-open stance and WMO commitments. Based on our assessments, no commercial entity, either domestic or foreign, can replace U.S. or foreign government satellite systems.

Over the years, the aerospace industry has evolved and grown. The 2010 National Space Policy supports a strong aerospace sector. NOAA depends on a strong private aerospace sector to develop its satellites. Over 80 percent of NOAA's appropriations for satellite services goes to the U.S. aerospace industry to help us build, launch, and operate these satellites. NOAA also purchases regional data from commercial companies that improve the reliability of our U.S. forecasts (e.g. Mesonet, lightning data).

In recent years, emerging elements of the aerospace industry have begun to invest private capital to build, launch, and operate satellites with the intent of selling data to private sector users and to the U.S. Government, and to NOAA in particular to support its weather mission.

[1] A comprehensive list of all laws, statutes, policies, and NWS directives guiding NOAA's use of weather related data is available in Appendix I.

NOAA welcomes this new role from the aerospace sector. In fact, NOAA spends at least $20 million in appropriated dollars annually to purchase commercially-provided satellite, lightning, airborne, and *in situ* data. NOAA anticipates purchasing more data over the coming years as the aerospace industry matures and develops new and additional data streams, and as NOAA has a chance to evaluate how these commercial sources of data can meet its operational requirements.

Before incorporating any data set, public or commercial, into our models, we must ensure that data is accurate, reliable, and can be validated. Though meeting data quality specifications cannot be our sole criterion: its impact on the highly valuable international data sharing regime must also be taken into account.

In this arrangement, the foundational environmental measurements are made available freely/without restriction to governments to use for the protection of life and property; to innovators or researchers with clever new products, and to entrepreneurs with promising new business models. Much of the economic value of the data comes from derived products generated by the private sector - analytical and tailored services - rather than from fees for the data.

The full U.S. weather enterprise is vivid proof of the tremendous tangible economic benefits this approach produces for our country. NOAA provides the output of weather models as well as the underlying data to the public that fuels these enterprises. According to the University Corporation for Atmospheric Research, the private sector is estimated to generate billions of dollars of annual revenue, employing thousands of people and providing a rich array of analytical products and tailored services to everyone from commodity traders to TV weathercasters. Examples abound of instances where the commercial weather sector has a role in this national weather enterprise and has monetized that role, from Google and its Earth Engine, to the Climate Corporation, which was sold to Monsanto for $1 billion, from the Weather Channel sale to NBC, to the sale of ocean data companies including GEBCO (General Bathymetric Chart of the Oceans).

NOAA's view, consistent with the 2010 National Space Policy, is that policies should facilitate the full, open and timely access to government environmental datasets on which the global enterprise and the global good depend. NOAA supports, and uses, private data purchase models in cases where the data improve our U.S. forecasts, and where lack of sharing does not undermine the forecasts of U.S. and other global partners. As noted earlier, data shared by our global partners gives us insight into weather that could be affecting the United States in a few hours, days, or weeks, and powers a vibrant private sector enterprise.

In order for NOAA to continue to provide increasingly relevant products and services to meet its mission, it requires full and open access to observational data - regardless of whether that data is

commercially-sourced or obtained from government developed systems - for local, regional, and global applications.

Conclusion

We live in a time when insight and foresight about the state of our planet is factored into individual and collective decisions to an extraordinary degree. These are decisions made at levels from head of household to head of state and have tremendous consequence for lives and livelihoods and the greater global good.

The space age made this possible. Satellites allow us monitor our global commons in near-real time on scales never before imagined. The ability to, in effect, take a snapshot of the planet has catalyzed the radical transformation in observations that we have witnessed over the past three decades.

And yet every day, across the entire globe, we also see evidence of needs for the right information, at the right scales, to reach the right people at the right time, to enable communities to make wiser decisions for their future and the future of the planet. There is much more work to do to develop new space sensors, new system architectures, denser *in situ* sampling, and further Earth system and computational research.

At NOAA, we are excited about the future. We think there is a very strong value proposition for being in the environmental intelligence service and we are eager to tackle these challenges. As the world changes, new business models may emerge. NOAA is changing to meet these challenges. While we also are assessing how the commercial sector may assist us in meeting those challenges, it is essential we obtain high assurances and validations before any policy changes on reliance on the source of data are enacted. We remain committed to keeping the proven U.S. and international data partnerships in place while the commercial sector demonstrates and validates its ability to meet our data requirements. Foremost is ensuring our mission protecting lives and property, securing critical infrastructure, and supporting a growing and thriving economy.

Thank you again for the opportunity to testify before you today. I am happy to answer any questions you may have.

Appendix I: A comprehensive list of all laws, statutes, policies, and NWS directives guiding NOAA's use of weather related data.

Statutes

Weather Service Organic Act, 15 U.S.C. § 313
Sets out the weather and meteorological reporting and forecasting responsibilities assigned to the Secretary of Commerce, including monitoring and recording climatic conditions.

Note to Weather Service Organic Act, 15 U.S.C. § 313 *note*
Public Law No. 101-595 (1990) - Authorizes NOAA to purchase Atmospheric Wind Data
Public Law No. 99-198 (1985) - Authorizes NOAA to provide agricultural and silvicultural weather services to Federal, state, and private efforts.

Space Weather Authority, 15 U.S.C. § 1532
Provides authority to: conduct research on all telecommunications sciences, including wave propagation and reception and conditions; prepare and issue predictions of electromagnetic wave propagation conditions and warnings of disturbances; conduct research and analysis in the general field of telecommunications sciences in support of other Federal agencies; investigate nonionizing electromagnetic radiation and its uses; and compile, evaluate, and disseminate general scientific and technical data.

User Fee Authority for the National Environmental Satellite, Data, and Information Service, 15 U.S.C. § 1534
Provides authority to assess fees, based on fair market value, for access to environmental data and information and products collected and/or archived by NOAA.

National Climate Program Act, 15 U.S.C. § 2901 *et seq.*
Authorizes a National Climate Program with responsibilities that include data collection, monitoring, analysis, assessment, and dissemination.

Global Change Research Act, 15 U.S.C. § 2931 *et seq.*
Provides authority for the development and coordination of a comprehensive and integrated United States research program to assist the Nation and the world to understand, assess, predict, and respond to human-induced and natural processes of global change.

Flood Control/River Forecasting Authority, 33 U.S.C. § 706

Authorizes agency expenditures in support of flood control, rivers and harbors, and related purposes, as well as for the establishment, operations, and maintenance by the NWS of the Hydroclimatic Network of precipitation stations to provide information on precipitation, flood forecasts, and flood warnings.

Tsunami Warning and Education Act, 33 U.S.C. § 3201 *et seq*.
This Act requires NOAA to operate a Tsunami Forecasting and Warning Program that is charged with providing tsunami detection, forecasting, and adequate warnings.

Meteorological Services to Support Aviation, 49 U.S.C. § 44720
This Act requires the Secretary of Commerce to provide meteorological services for aviation in coordination with the Federal Aviation Administration.

Regulations

Modernization of the National Weather Service, 15 C.F.R. Part 946

Menu of Services, 15 C.F.R. 946.4
The basic weather services provided by the National Weather Service are: surface observations; upper air observations; radar observations; public forecasts, statements, and warnings; aviation forecasts, statements, and warnings; marine forecasts, statements, and warnings; hydrologic forecasts and warnings; fire weather forecasts and warnings; agricultural forecasts and advisories; NOAA Weather Radio Broadcasts; climatological services; emergency management support; and special products and service programs.

Policies

NOAA Policy on Partnerships in the Provision of Environmental Information, http://www.noaa.gov/partnershippolicy/

OMB Circular A-130, Management of Federal Information Resources, http://www.nws.noaa.gov/im/omblink.htm. .

WMO Resolution 40, **WMO Policy and Practice for the Exchange of Meteorological and Related Data and Products Including Guidelines on Relationships in Commercial Meteorological Activities**
http://www.wmo.int/pages/about/Resolution40_en.html

WMO Resolution 25 (Cg-XIII), Exchange of hydrological data and products
http://www.wmo.int/pages/about/Resolution25_en.html

NWS Directives

NWS Policy Directive 1-10, Managing the Provision of Environmental Information
http://www.nws.noaa.gov/directives/sym/pd00110curr.pdf

NWS Policy Directive 10-17, Dissemination
http://www.nws.noaa.gov/directives/sym/pd01017curr.pdf

NWS Instruction 10-1710, NOAA Weather Radio (NWR) Dissemination
http://www.nws.noaa.gov/directives/sym/pd01017010curr.pdf

NWS Instruction 10-1711, NOAA Weather Radio All Hazards (NWR) Systems Management
http://www.nws.noaa.gov/directives/sym/pd01017011curr.pdf

NWS Policy Directive 10-18, Service Outreach
http://www.nws.noaa.gov/directives/sym/pd01018curr.pdf

NWS Procedural Directive 10-1806, NWS Support for Special Events
http://www.nws.noaa.gov/directives/sym/pd01018006curr.pdf